

A Comparison Between Chemical and Electrochemical Methods for the Reduction of Hexavalent Chromium in Aqueous Solution

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Hexavalent chromium Cr(VI) is a major pollutant present in industrial waste waters such as those from metal processing, mineral processing and plating. Cr(VI) is considered carcinogenic and mutagenic. Also, it diffuses speedily through soils and aquatic environments and is a strong oxidizing agent readily absorbed through the skin; even at small quantities it irritates plant and animal tissues [1,2]. The most probable Cr(VI) species in aqueous solution are $\text{Cr}_2\text{O}_7^{2-}$, CrO_4^{2-} and HCrO_4^- , the relative distribution among these chemical species depends on pH and Cr(VI) concentration [3]. However, none of them form an insoluble species of the pollutant, such that its separation is not feasible from the wastewater through a direct precipitation method [4].

In order to significantly reduce the concentration of the said pollutant in aqueous solution while being simultaneously converted to trivalent chromium (which is a thousand times less toxic than Cr(VI)), the present work describes a series of experiments in which chemical and electrochemical reduction methods are compared. The chemical methods tried in this study, used as reducing agents NaHSO_3 and $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$; whereas in the electrochemical technique iron electrodes (both: the cathode and the anode were employed in an electrochemical cell) for the same purpose.

Chemical reduction should takes place at acidic conditions, pH values below about 3.0. As this process consume protons during their development, it is necessary to supply some mineral acid for maintain low pH condition [5]. Moreover, it is required to add an excess of the stoichiometrical quantity (10 %) of reducing agents to achieve the Cr(VI) reduction that meets environmental standards after precipitation of the resulting Cr(III). The main disadvantage of this method is the large amount of sludge generated during the Cr(III) precipitation stage. As a result, the management and final disposal of this residue is quite difficult.

On the other hand, the electrochemical process

involves the liberation of ferrous ions in solution by means of the anodic polarisation of an iron metal electrode [6,7]. These Fe(II) ions, in turn, induces the Cr(VI) reduction present in the aqueous solution. The reactions that take place are favoured by low pH values, namely 2 for the present case. In this work it is show that there is a significant difference between the theoretical mass of iron needed to reduce Cr (VI) and the quantity required in the actual electrochemical experiments (according to Faraday's Laws: up to 30 %). From the environmental point of view, this result is encouraging since there are smaller quantities of sludge produced. This fact that has a significant impact on lowering final disposal costs, beside it decreases the environmental impact.

Based on the Chemical and Thermodynamical characteristic of the Cr(VI)-Cr(III)-Fe(II)-Fe(II)-H₂O system, an Electrochemical Reactor that meets this features is proposed.

The above system was electrochemically characterized using both stationary and non-stationary techniques. Furthermore, the sluge was analized through Scanning electron microscopy and X-ray diffraction microanalysis.

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